

# Quantum Institute Workshop

Quantum Institute Briefing Center; December 9–10, 2002

## The Experimental Potential for Laser-Cooling Molecules

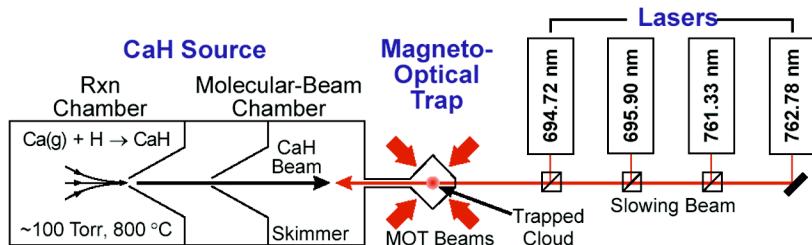
Michael Di Rosa, Bob Sander, Dave Vieira, and Steve Buelow  
Los Alamos National Laboratory

Sponsors:

Los Alamos LDRD-ER  
DOE-NNSA (NA-22)



### Concept: MOT Capture of Laser-Slowed Beam



- Laser Cooling and MOT for Molecules Not Previously Attempted
- Paramagnetic Alkaline-Earth Hydrides (e.g. CaH) are Prime Candidates for Laser Deceleration and MOT Confinement



Presenter: Michael Di Rosa

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### Topics/Applications Stimulated by Ultracold Molecules

#### Basic Molecular Physics

- New molecular scattering regime of  $E_{int}$  ( $\sim 10$  K) >  $E_{trans}$  ( $< 100$   $\mu$ K)
- Studies Possible with BeH (theoretical benchmark of open-shell molecules)
- Molecular BEC (CaH) and Fermi-degenerate gas (CaD)
- Entangled Atom Pairs from Photodissociation
- New Theoretical Challenges (Russell Pack and Bob Walker, T-12)

#### DOE/NNSA Interest

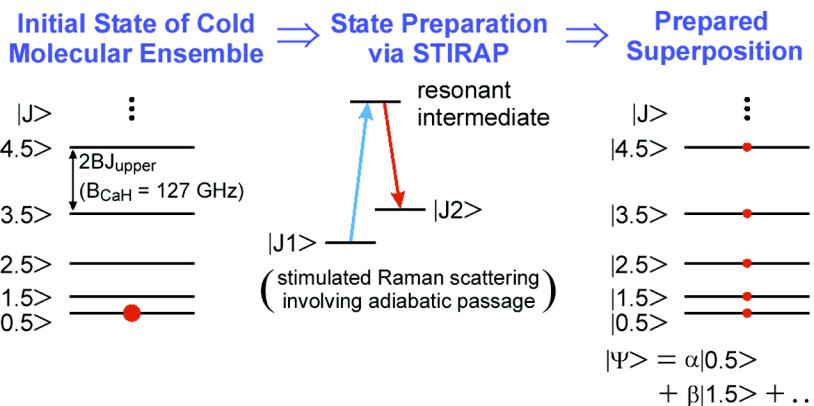
- Molecular Interferometry (gravity gradiometry, underground-structure detection)
- Low-Temperature Relaxation (relevant to isotope separation)
- Ultrasensitive Tritium Detection via CaT Trapping

#### Quantum Information (??)

- Entangled Atom Pairs from Photodissociation
- Quantum Bits/Bytes from Molecular State Preparation and Coherence



### Molecular-State Manipulation Viewed for QI



- Level Spacings  $\sim 100$  GHz  $\sim 5$  K
- No Initial Thermal Distribution, No Thermal Randomization for  $T < 5$  K
- Decoherence Inhibited for  $\Delta J = 2$  Spacing
- Readout Possible through Laser-Induced Fluorescence



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**Magnetic-Level Registers of Level J in B-Field**



- $10^3 \times$  greater level separation per unit B, compared with NMR
- Number of Registers  $(2J+1)$  Selectable by J
- Amenable to NMR-type operations
- Quantum Bytes Buildable from Bits of  $m_J$  Pairs
- Readout through Polarization Effects or Stern-Gerlach Analyzer

